
Mutual Joint Visit Workshop for Seveso Inspections
SAFETY CULTURE, LEADERSHIP, AND ENFORCEMENT
16-18 September, 2015, The Hague, The Netherlands

**Inspections following major
accident in a chemical
establishment: management
perspectives and repercussions
on company safety culture**

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Issues

- ▶ Presentation of **inspections carried out after an accident** that occurred at a chemical Italian establishment under Seveso directive
- ▶ Analysis of the **technical and organizational factors** related to the accidental causes
- ▶ Focus on the **corrective actions taken by the operator** after the accident, with specific reference to Safety Management System (SMS) issues
- ▶ Lessons learned and return of experience regarding the **company safety culture**

Introduction: the role of ISPRA for industrial risk control

- ▶ ISPRA (Italian National Institute for Environmental Protection and Research) has a national role as a technical body supporting the Ministry of Environment in the national implementing of the Seveso Directives
 - ▶ Definition of technical contents of laws and decrees to control Major Accidents
 - ▶ Set-up of the National Inventory of major accident hazards establishments and other related data-bases
 - ▶ **Inspections of upper-tier establishments SMS on regular basis or after an accident**
 - ▶ Support for international activities (EU, OECD, bilateral cooperations)
 - ▶ Technical coordination and addressing of Regional Agencies for the Protection of Environment (ARPA)
 - ▶ Collaboration with other Authorities competent for industrial risk (Ministry of home affairs – National Fire Brigades; Department of civil protection; Ministry of infrastructures)

(eMARS database – Major Accident Reporting System)

- ▶ Location/Date/Time of Major Occurrence
 - ▶ Lombardia Region - north of Italy; 10/09/2013; h. 4.00
- ▶ Accident title
 - ▶ Flash-fire during upload of DMC (Dimethyl carbonate) under vacuum condition
- ▶ Accident type
 - ▶ Major Accident, reported under Seveso II Directive
 - ▶ Seveso II status of the establishment: art. 9 – upper tier (SR - Safety Report)
- ▶ Industrial Activity
 - ▶ General chemicals manufacture
- ▶ Reason for Reporting (Annex VI of Seveso Directive)
 - ▶ Injury to persons: 1 death

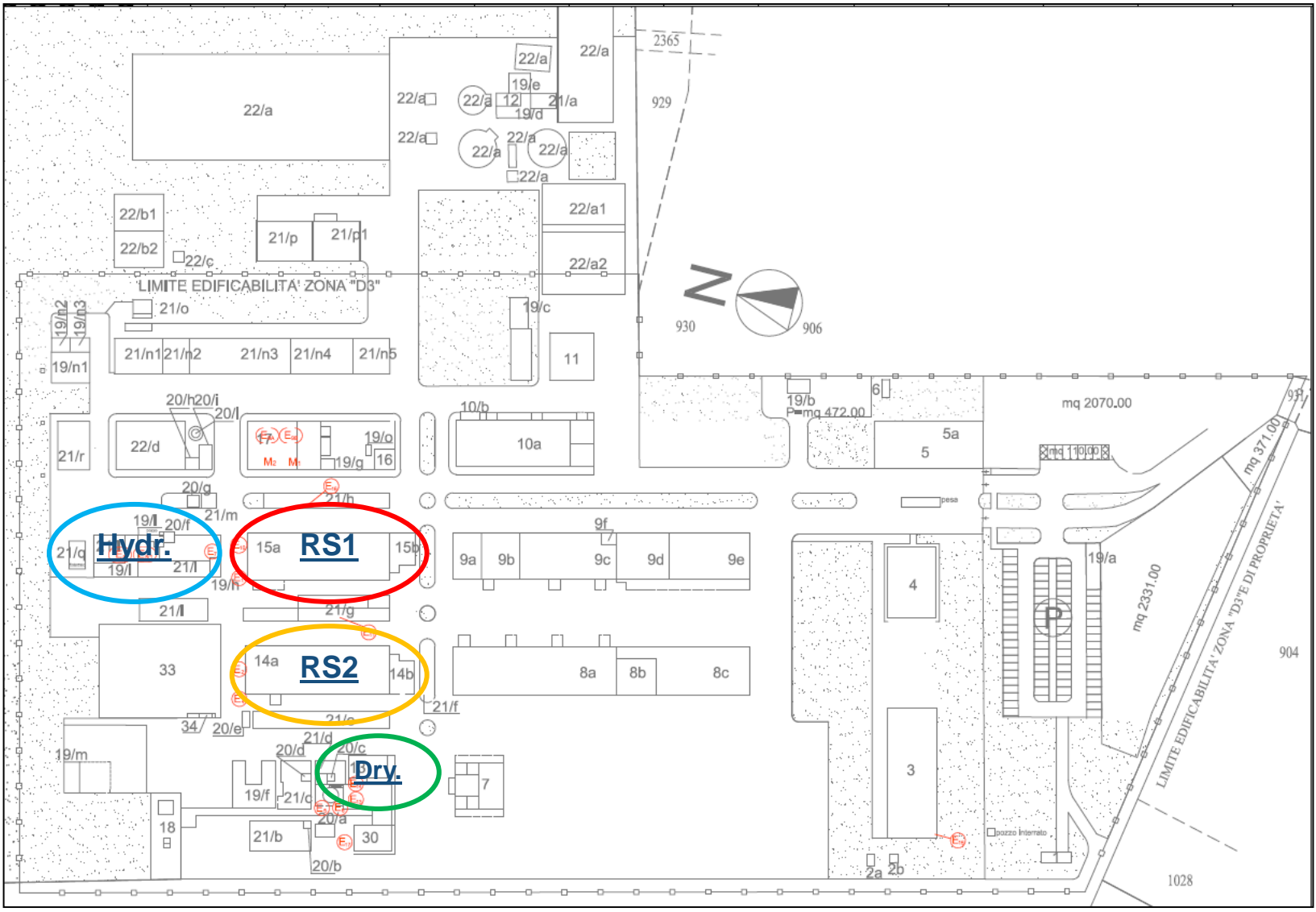
“On site” Inspection following accident (Feb. 2014): the inspection mandate

- ▶ A commission is charged by Ministry of environment and it is made up by 3 members from:
 - ▶ ISPRA
 - ▶ National Fire Brigades (CNVVF)
 - ▶ Institute for Accident Prevention and Safety at Work (INAIL)
- ▶ The commission should investigate the dynamics of the event to determine whether the accident is considered “major” or presents particular technical interest for preventing major accidents and mitigating their consequences
- ▶ The commission should collect information and data using the eMARS database
- ▶ The commission must prepare a final technical report which states the description of the causes, dynamics and consequences of the accident

Site description: headquarters of an international industrial group

- ▶ Chemical establishment for the manufacture of auxiliary products for textile industry with the production departments
 - ▶ **RS1: chemical synthesis processes**
 - ▶ RS2: mixtures, formulations and simple synthesis reactions
 - ▶ Drying: products are subjected to a drying process to be sold in the form of powders packed in sacks or big-bags
 - ▶ Hydrolyzation: production of phosphorous acid and hydrochloric acid by phosphorus trichloride
 - ▶ These plants are connected to
 - ▶ Storage areas and warehouses for raw materials, intermediate and finished products in cylindrical tanks, drums or IBC (Intermediate Bulk Container), bags
 - ▶ Technical facilities, laboratories, offices and services

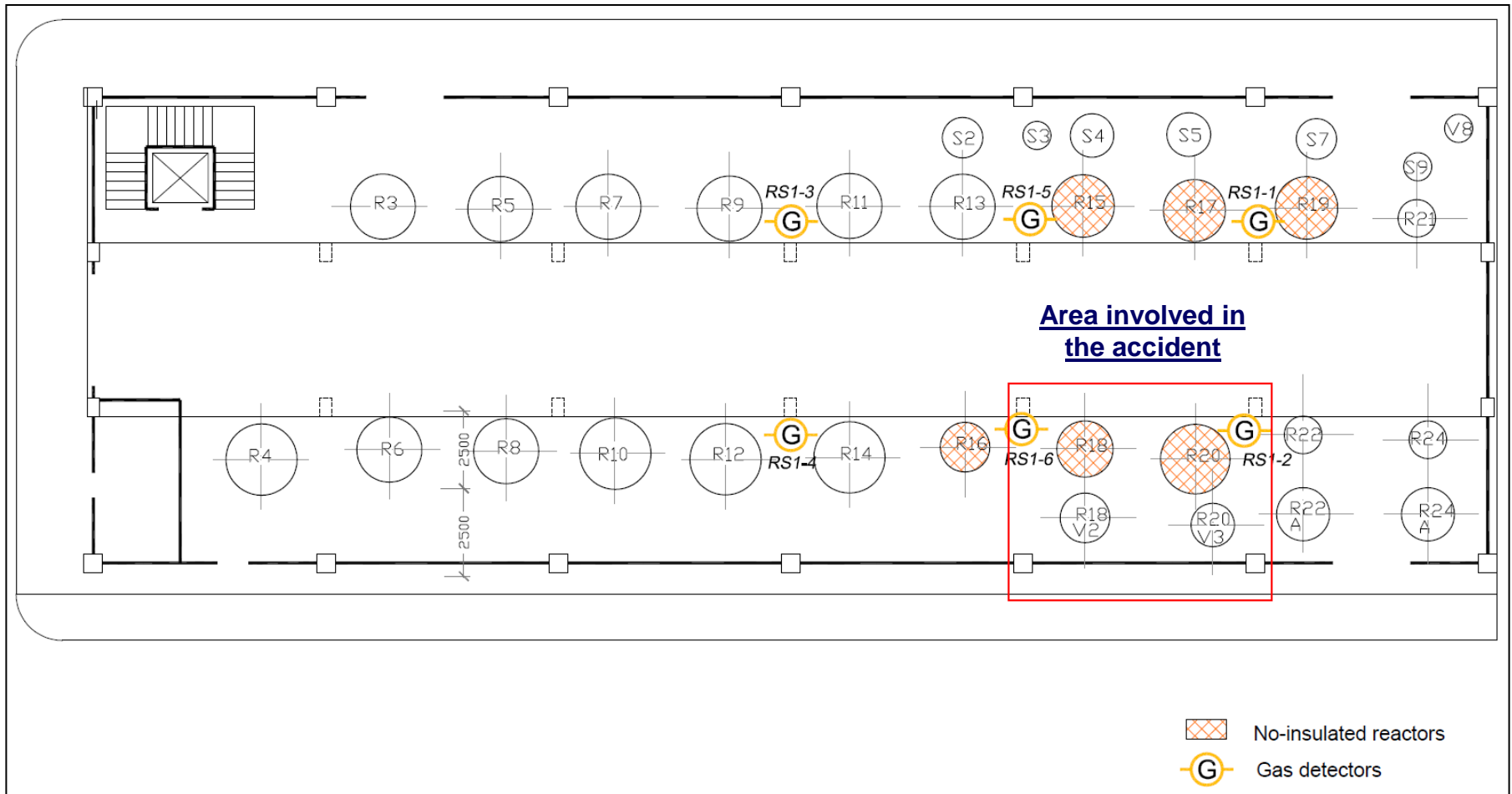
Plan of the establishment



Installation description: RS1

- ▶ 20 internal lines of production and 6 external neutralizing units are used for the production of synthesis finished or intermediate products, through processing of raw materials from storage tanks, drums or warehouses
- ▶ Each reactor is destined to its own batch processing. **The reactor R20 can be used for various types of reactions**
- ▶ The reactors are arranged in two opposite rows with a loft so as to leave a corridor for the internal handling. On the first floor of the loft there are the dashboards. The op. unit mainly operates in the Control Room by PC process
- ▶ **The loading of raw materials is performed** by tank through fixed pipes or **by drum placed on the floor through suction pipe** or directly from the hatch (solids or powders)
- ▶ The unloading of the product into storage tanks is carried out by foot valve through pump or air/nitrogen pressure
- ▶ The internal handling of drums or bags is done by trucks

Plan of the production department RS1



Accident report

- ▶ On 10/09/2013, at 4:00 am, two operators were concluding the loading phase of Dimethyl carbonate in the R20 of the RS1 from **200 liters metal sheet drums**, by vacuum suction with flexible pipe connected to the reactor, for a total of 849 kg (open cycle transfer)
 - ▶ To empty the **4th drum** (10-15 lt. remaining), **it was inclined to facilitate the suction**
 - ▶ Probably in the next step of **extraction of the loading nozzle**, it was produced the **ignition of DMC vapors**
 - ▶ **Explosion of the drum with bottom detachment and consequent immediate fire** of the whole product, with a limited impact area (about **2 mt.**) and a limited duration of the entire event of about **10 min.**

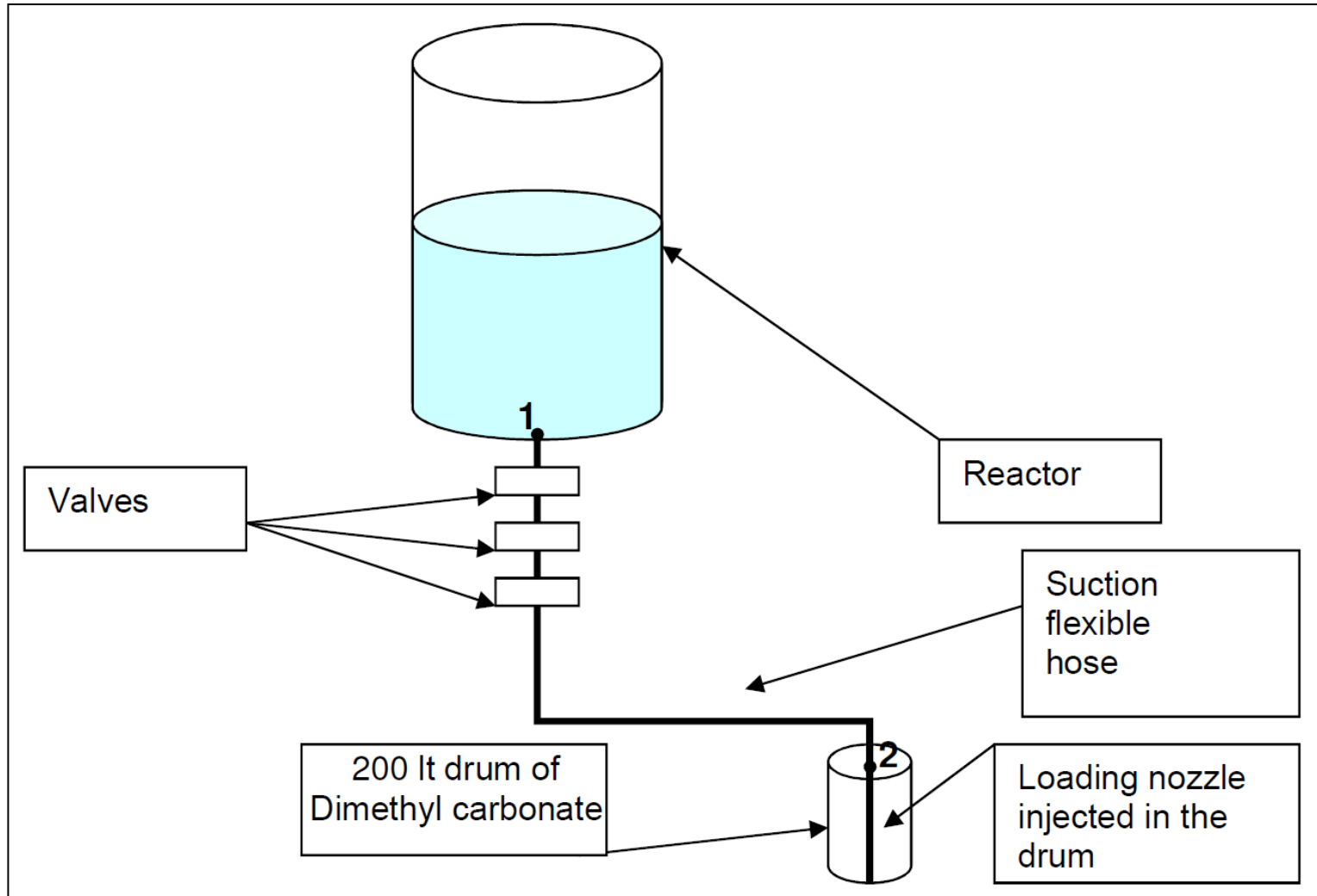
Substance involved: DMC (Dimethyl carbonate)

- ▶ **DMC** (CAS n. 616-38-6): liquid at ambient temperature, used as a reagent for synthesis
 - ▶ The substance is classified: **Highly flammable liquid and vapor** (R11 – H225)
 - ▶ 07b HIGHLY FLAMMABLE LIQUIDS (under Seveso II Directive, Annex I, Part 2)
 - ▶ P5c FLAMMABLE LIQUIDS (under Seveso III Directive, Annex I, Part 1)
- ▶ The product is purchased in **drums of metal sheet of 200 liters capacity**, which are kept in storage at the plant for subsequent use
- ▶ The quantity of substances **involved in the event is about 10 kg** (estimated by the operator)

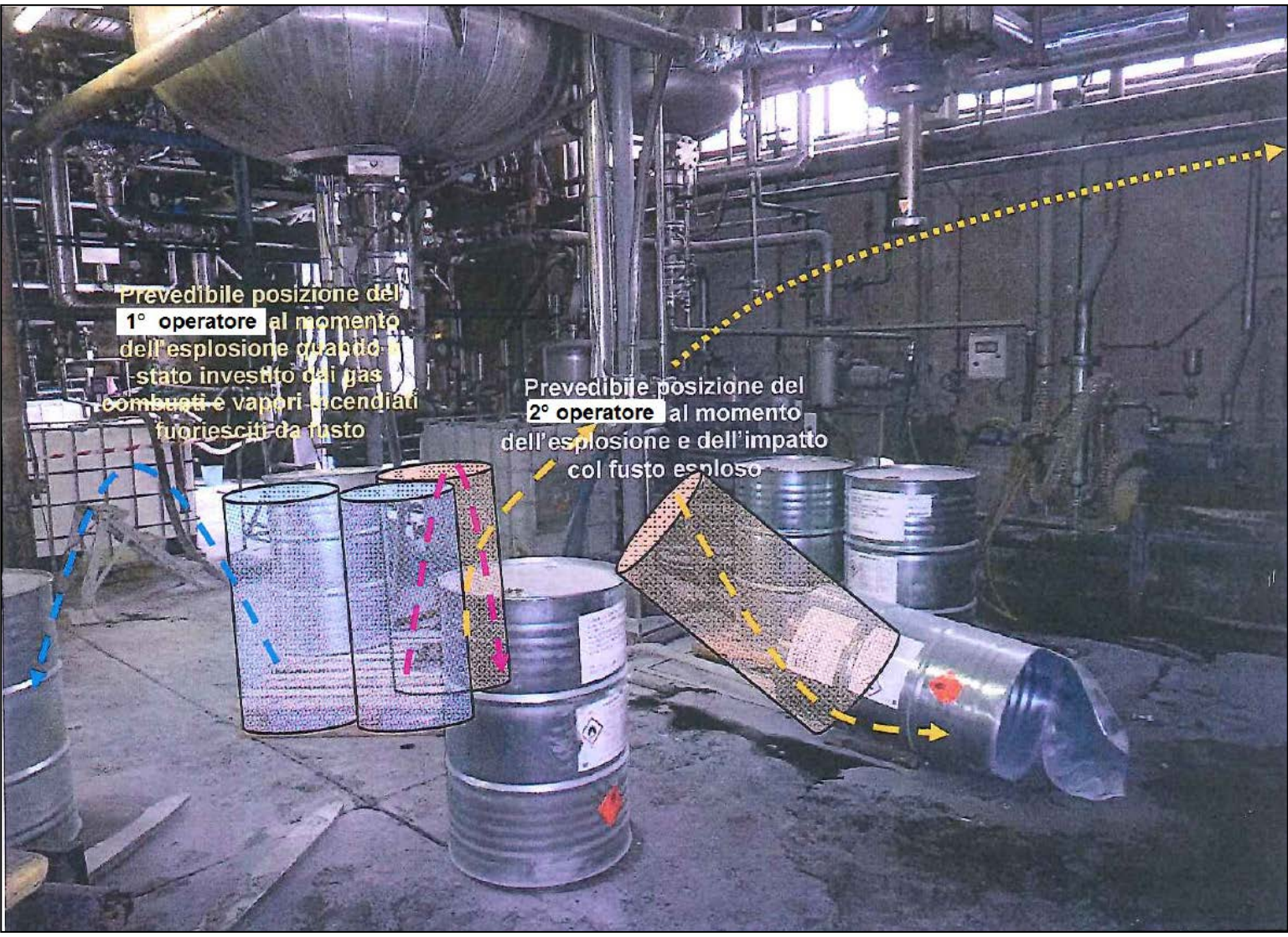
Consequences

- ▶ **The first operator**, responsible for handling of flammable, **was hit by a presumable flash fire of DMC and seriously injured**
 - ▶ He was transferred to a specialized center for the treatment of the burns
 - ▶ Later he died after 10 days of hospitalization because of burns on most of the body
- ▶ **The second operator**, supporting the handling operations, **fell to the ground a short distance away and was slightly injured**
 - ▶ He was treated in hospital and then dismissed (bruises and limited burns)
 - ▶ He returned to the company after 36 days of injury, having also reported psychological trauma

Connection diagram of the reactor to the drum



Area involved: predictable trajectory of the drums and dynamics of the event



Views of the whole area involved



The connection system: the reactor – the flexible hose – the loading nozzle – the drum



Damage to the installations and equipment (1/2)



- ▶ Pallet damaged area by the exploded drum

- ▶ The exploded drum

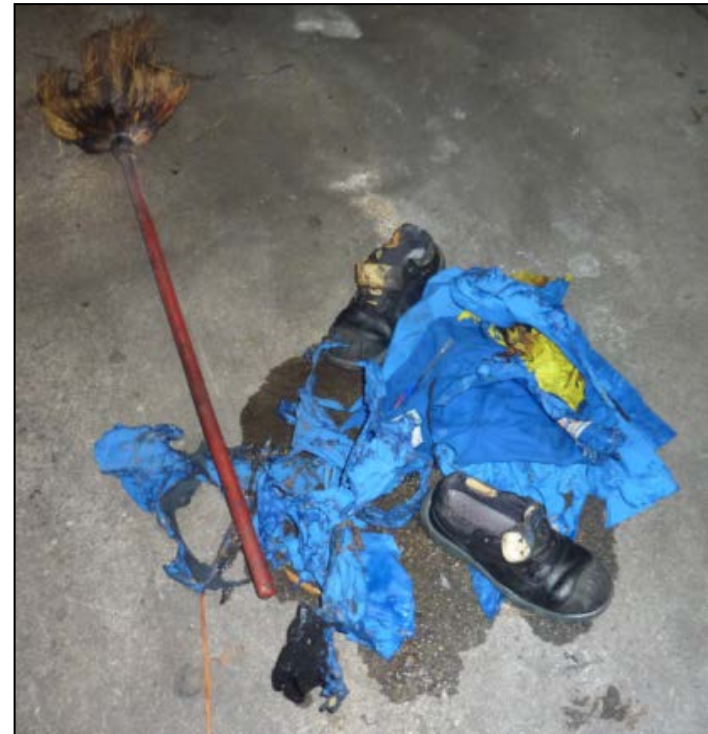


Damage to the installations and equipment (2/2)



- ▶ The flexible hose and the loading nozzle

- ▶ The remains of Personal Protective Equipment (PPE)



Causes of the accident: technical and organisational factors

- ▶ The cause of the fire triggering is reasonably to be found in the accumulation of electrostatic charges on the hose and nozzle, both in plastic material, following the repeated insertion and removal of these same in the drums (final phase of the loading operations)
 - ▶ Such material is not compatible with the manipulation and handling of flammable substance (dielectric properties)
- ▶ The procedure for handling flammable, in effect at the time of the event, gave general indications about the chemical compatibility and the grounding system and the correct identification of the specific equipment to be used
- ▶ According to interviews with some workers, there was not a specific training on the handling procedure

Emergency response

- ▶ At the time of the event there were in the area only the two operators involved in the accident
- ▶ In the early stages (within minutes) the shift supervisor and other department and laboratory workers, following the noise created by the event, rushed from the top floor and the ground floor
- ▶ **Laboratory workers** have made some **first aid**
- ▶ The communications officer made the **emergency call** and alerted H&S Manager and other corporate executives
- ▶ Ambulances, police, Fire Brigade, medical car arrived on the site
- ▶ After the events, the company's staff has **completed the interrupted operations**, with the approval of the present authorities, solely for the **purpose of making safe the reactor**

Prevention and mitigation measures taken by the company

- ▶ The company has quickly (16/09/2013) issued, as part of the SMS, a **new version of the procedure for handling flammable with more detailed and more explicit information** about
 - ▶ **chemical compatibility** of the loading equipment with the properties of the flammable products
 - ▶ **grounding system** of the containers for the reactor loading
 - ▶ correct and easy **identification of specific equipment**
- ▶ It is currently **being studied** by the company
 - ▶ A new **fixed type loading system** of the flammable raw materials, in a **closed cycle and/or in a nitrogen atmosphere**, from the mobile containers, in order to remotize the possibility of unfitting operation

The new procedure for handling of flammable raw material: basic standards of good practice

- ▶ Using **nozzles of stainless steel and conductive pipe** that are chemically compatible with the specific loading raw materials
- ▶ **Loading possibly from the foot valve** of the container in order to avoid turbulence
- ▶ Do not exceed the **loading speed of 100 lt./min** (av. speed of 1 m/s)
- ▶ **Loading possibly by vacuum** produced in the container in which the raw material loading is carried out
- ▶ **Loading the raw material in exact order** as described in the manufacturing process
- ▶ Checking **the correct grounding system** in case of conductive equipment (stainless steel nozzle and/or conductive pipe)
- ▶ Check regularly **the electric continuity of the “nozzle + conductive pipe”** equipment (electrical bonding) - every 6 months
- ▶ **Do not climb** on wooden pallets
- ▶ Keep the **packed containers separated** from each other

The new procedure for handling of flammable raw material: operational instructions and easy identification of equipment

► Compatibility, containers and loading instructions

Compatible materials during the loading	
AAAA	Good compatibility with stainless steel - AISI 316
BBBB	Not compatible with stainless steel - AISI 316
Packed container	
1	Lacquered iron drum
2	Polyethylene IBC, iron cage and wooden pallet
3	Polyethylene IBC, metal sheet cage and pallet
4	Iron / steel drum
5	Iron can
Loading instructions	
Load 1	Loading in reactor through external pump and dedicated spiral steel pipe with grounding system
Load 2	Loading from under the reactor through stainless steel nozzle and conductive pipe
Load 3	Taking from small container (drum) and loading from work desk by barrel
Load 4	Loading from work desk by pump from 20-25 lt. can
Load 5	Loading from work desk through stainless steel nozzle and conductive pipe

► Chart of the equipment: the case of DMC loading

Raw Material name	Compatible materials during the loading	Packed container	Reactor	Loading instructions	Neutralizing agent	Liters
DMC	AAAA	4	R20	Load 2	Water	20

- ▶ **The Medical Prevention Department** - Office of prevention and safety at the workplace, intervened at the scene (5.30 am) to **rescue the injured**, providing the **prohibition on the use of the installation** ending at 15.00 on the same day, to allow the making safe of the reactor
 - ▶ The day 19/09/2013, it ordered the **requisition of equipment** in use at the time of the accident (drums, hoses and loading nozzle), **and the remaining Personal Protective Equipment**
- ▶ **Local Fire Brigade** (Technical Regional Committee), following the accident, **charged a working group to acquire more information through “on site” inspection (30/10/2013) and documentation request to the company**
 - ▶ Accident circumstances
 - ▶ Hazardous substances
 - ▶ Accident consequences for human and environment
 - ▶ Emergency measures taken
 - ▶ Measures taken to limit the effects in the medium and long term and to avoid any recurrence

SMS Inspection (Oct. 2014): the inspection mandate

- ▶ A commission is charged by Ministry of environment and it is made up by 3 members from:
 - ▶ ARPA (Environmental Protection Regional Agency)
 - ▶ Local Fire Brigades – Regional Technical Committee
 - ▶ Institute for Accident Prevention and Safety at Work
- ▶ The commission must verify the **suitability of the operator MAPP (Major Accident Prevention Policy)** carrying out a planned and systematic examination of the systems being employed at the establishment, whether of a technical, organisational or managerial nature
- ▶ ...
- ▶ The Commission shall include in the final report, among others, specific information about **corrective actions taken by the operator in order to overcome the criticalities emerged as a result of the accident** happened on 10/09/2013
- ▶ ...

Corrective actions taken after the accident: the operator analysis on the technical and organisational factors

Date: 10/09/2013	Title: Fire of DMC remains in drum with explosion and flash fire		
Synthetic description: During the DMC loading from drum to reactor, at the ending of the 4 th drum loading, vapors inside the drum fired by primer and overpressure opened the drum with explosion. Leaked vapors caused a flash fire that hit the handling operator			
Organizational factor	Description	Actions taken	Expected / Planned actions
Operating procedures and instructions in normal, unexpected and emergency conditions	Operational error of the worker during the loading – wrong nozzle	Replacement of all the nozzles used for the flammable loading	Training action for operators
Operating procedures and instructions in normal, unexpected and emergency conditions	Error likely caused by negligence and/or haste	The shift supervisors should carefully monitor the implementation of activities involving specific risks	Obligation to audit, by department head / shift supervisor, the use of correct practices

Corrective actions taken after the accident: the commission acknowledgment

- ▶ It is currently carrying out the **judiciary inquiry** with a request for assessments by the **Technical Office Consultants and the expert witness**. Technical assessments have been submitted, but they are still not the final ones
- ▶ **Temporary Suspension of the DMC use** within the site until the completion of evaluations relating to Quantitative Risk Analysis
- ▶ *Implementation of the new procedure for the flammable handling, checking the **development of “on site” training events through learning verification** (SMS Inspection requirement)*
- ▶ *It was recalled the **obligation of grounding system for all plastic containers** and the periodic **check** of the equipment **electrical continuity** (Local Fire Brigade requirement)*
- ▶ **Replacement of all nozzles** for the flammable transferring with loading nozzles of **stainless steel** and **conductive pipe**
- ▶ **Medical interviews** of the workers with psychologists of the department of clinical psychology hospital about **Post-Traumatic Stress Disorder** (PTSD)

An apparently minor event

- ▶ Ending of loading operation (4th drum, 15 lt. remaining): likely negligence and haste of the workers
- ▶ Wrong equipment (loading nozzle and hose in plastic material)
- ▶ High speed of loading in conjunction with the drum position (inclined)
- ▶ Minimum amount of a “Seveso” flammable substance involved in the event (10 kg.)
- ▶ Short duration of the event (10 min.)
- ▶ Limited area of impact (2 mt.)
- ▶ One seriously injured worker (1 death) and one slightly injured

***Not a safety at work event, but
A MAJOR ACCIDENT!***

- ▶ The risk generated by **the accumulation of electrostatic charges, during the loading/unloading/transfer operations of flammable liquids from small containers, is underestimated**
 - ▶ **In the establishment risks analysis there was no trace of this accidental hypothesis** and consequent damage scenario, although there were **all conditions to result in a fire ignition** (loading flammable product, electrostatic charge like fire triggering)
 - ▶ This risk has not been assessed probably **due to the ease of execution and to the repetitiveness** of these transferring operations (routine)
- ▶ It's necessary **to check all the possible causes** that led to the accident, as well to assess **the impact of even the less significant with a low occurrence probability**

Lesson learned and return of experience: repercussions on company safety culture (2/2)

- ▶ The likely **operational errors** of the worker, combined with the possible negligence and/or haste, represent the **effect of a corporate safety culture that is not adequately developed**
 - ▶ Any “shortcuts”, that could save time and money, actually involve taking unnecessary risks
- ▶ **Malfunctions and criticalities of the managerial** and organisational perspectives have an affect on the behavior of the workers, **overstating any operational errors**
 - ▶ **Supervisors, H&S Manager and corporate executives** must always show their **commitment to safety**, monitoring the correct implementation of specific risk activities
 - ▶ **All employees** must exhibit a working **knowledge of safety topics**, through participation in training programs and the consequent use of the correct work instructions

- ▶ **Specific management measures** are indispensable to control the risk of charges accumulation in flammable transferring
 - ▶ Correct operational **procedure** (chemical compatibility, containers, loading instructions)
 - ▶ Specific **equipment** (loading system, grounding system, PPE)
 - ▶ Detailed **training** (“on site” events, learning verification)
 - ▶ Possible **use of transfer systems in a closed cycle**
- ▶ On the occasion of the **SR technical examination and SMS inspections**, it would be appropriate to investigate, among others, the **technical and management systems put in place to prevent the specific risks generated by flammable liquids transfer from small containers** (i.e. drums, bags, IBC)

Thanks for the attention!

Any question?

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